Protecting Space Assets Through Denial Deterrence

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Overview

- The challenge of protecting space assets
- Deterrence concepts
- Denial deterrence for space
- Examples from the IT world
- Towards a space protection strategy
- Key enabling technologies
THE CHALLENGE OF PROTECTING SPACE ASSETS
Kinetic threats to satellites

Chinese SC-19

Soviet Co-Orbital

US ASM-135

US Aegis SM-3
“The last Titan rocket, 4B-26, was launched on Oct 19. It deployed USA 186, a classified NRO satellite, into polar orbit. 

**Hobbyists have observed the satellite and determined its orbit to be 264 x 1050 km x 97.9 deg. This confirms that the satellite is one of the imaging reconnaissance satellites, replacing a satellite launched in 1996.”**

– Jonathan's Space Report, Nov 2005

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1 28888U 05042A 08229.08029740 00005163 00000-0 48953-4 0 07
2 28888 97.9296 290.4131 0543547 73.9612 292.0741 14.75806181 00
The problem with reactive maneuvers...

- Kill chain executes faster than the protection chain

**Fully automated**

- Detect Launch
- Determine booster AZ
- Assess threatened satellites
- Communicate threat to correct satellite operator
- Calculate evasive maneuver
- Command satellite to maneuver

- Less than 15 minutes
- BOOM

**Human decision makers**

- Could *possibly* solve the answer with on-board auto-detection systems
- Physics of last minute maneuvers almost impossible (delta-v)
- False alarms (Sun glints? Passing debris?) and spoofing prevention
- What’s the risk of accidental airbag deployment?
Maneuvering high-value satellites before crossing into hostile territory would put them out of range of direct ascent ASATs. **but:**

- What’s the quality of your intelligence on the ASAT locations?
  - Are the ASATs mobile?
- How do these avoidance maneuvers affect the ability of these satellites to conduct their missions?
  - Sun-sync: change in altitude requires change in inclination, both affect ground-track repeat
- How many times can you do this before fuel is an issue?
  - 10 ASATs at < $100M each force a $1B satellite to maneuver 10 times for 100% of its fuel = Attacker Win

If a maneuvered satellite cannot fulfill its mission, the attacker wins!!
DETERRING ATTACKS ON SPACE ASSETS
What is deterrence?

deterrence (noun):

1) the act or process of discouraging actions or preventing occurrences by instilling fear or doubt or anxiety

2) a communication that makes you afraid to try something

3) a negative motivational influence

See also: discouragement, intimidation, disincentive

This is known as reprisal deterrence
Common forms of reprisal deterrence
The usual military approach to deterrence

More Bombs Deter More. Next Slide Please.
My personal experience with deterrence success...

- Feb 2000 – March 2004
- 275 alerts
- 12th Missile Squadron, Malmstrom AFB
...and failure

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Another way of looking at deterrence

denial deterrence:

*deterring attacks by removing any advantage an attacker would gain*
Elements of denial deterrence for space assets

- **Shift from one/few critical nodes to many nodes**
  - Presented here by Dr. William Marshall of NASA AMES last year

- **Redundancy on multiple levels**
  - Multiple satellites in same orbit regime and across different orbit regimes providing same function
  - Robust links between space, air, sea and ground systems

- **Easy node replacement**
  - Smaller, lighter, cheaper satellites
  - Faster, more agile acquisition cycle
  - Operationally Responsive Space
Many nodes in a satellite system

<table>
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<th>System</th>
<th>Notional Current</th>
<th>Proposed MMCA</th>
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<tr>
<td></td>
<td># of Nodes</td>
<td>Size Each</td>
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<td>Early Warning</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td></td>
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<td></td>
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*numbers taken from Astropolitics paper by William Marshall*
Redundancy on multiple levels

- GEO
- MEO
- LEO
- UAS
- Ground
- Landlines
- Internet

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Ease of nodal replacement

- Utilize cheaper SLVs
- Increased number of launches
- Cheaper costs and technology development

Launch Costs

- Economics of scale
- Standardized buses
- Incremental upgrades

Satellites

- Much smaller in size
- Shorter on-orbit lifetimes
- Reduced need for failure tolerance

Acquisition Efficiencies
EXAMPLES FROM THE IT WORLD
Google’s Approach

- 400,000+ nodes made of small, cheap PCs (maybe more...no one knows for sure)
- Data and applications distributed across all nodes
- Separate power grids, separate data backbones
A POSSIBLE WAY FORWARD
Towards a space protection strategy

- Shift development of future space systems towards redundant constellations of microsatellites
  - Exploit acquisition and manufacturing advantages
  - Design systems that are interchangeable, interleaving, and flexible for the end user

- Funnel adversaries towards non-kinetic means
  - Jamming, hacking, spoofing
  - Dangerous, yes, but probably non-destructive attacks which will leave asset intact and not impact long-term sustainability of space

- Focus on increasing defenses within this reduced attack surface
Inherent advantages

- Doesn’t need to be specifically crafted for a certain adversary in a certain situation

- Don’t need to know who the adversary is (only method of attack)

- Don’t actually need the adversary to be deterred
  - if system is truly distributed and redundant then any kinetic attacks will have little to no effect on overall system performance
• Microsatellites
  – SurreySat

• Optical interferometry
  – ESA LISA Pathfinder

• Packetized, routable, delay-tolerant data traffic (i.e.“Routers in space”)
  – IRIS (Internet Router Protocol in Space), UK-DMC Satellite

• Laser communication links
  – NFIRE, TSAT
I’m not the first one to think of this concept

- DARPA F6 program
- Future, Flexible, Fast, Fractionated, Free-flying
Bottom Line

• Deterrence does have applications for protecting space assets, but not necessarily in the classical sense

• Denial deterrence and the shift towards distributed, redundant, microsatellite infrastructure is the primary means of defeating kinetic ASAT weapons

• Denial deterrence should be part of an overall Space Protection Strategy

• US must put as much intellectual analysis into space security concepts as it did Cold War strategies
  – See recent Council on Foreign Relations report on China
Many Thanks
Any Questions?

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